A Preliminary Study of Variability in Year-Class Abundance of Post-Larval and Juvenile Lingcod in the Strait of Georgia during 1980-82

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A PRELIMINARY STUDY OF VARIABILITY IN YEAR-CLASS ABUNDANCE OF POST-LARVAL AND JUVENILE LINGCOD IN THE STRAIT OF GEORGIA DURING 1980-82

by

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ABSTRACT

Cass, A. J. and J. R. Scarsbrook. 1984. A preliminary study of variability in year-class abundance of post-larval and juvenile lingcod in the Strait of Georgia during 1980-82. Can. MS Rep. Fish. Aquat. Sci. 1755: iv + 27 p.

Purse seine and bottom trawl surveys were conducted in the Strait of Georgia to estimate the relative strengths of the 1980 and 1981 year-classes of post-larval and age-1 lingcod in the Strait of Georgia. Densities of post-larvae compared favorably with a strong 1975 year-class. As a result, strong 1980 and 1981 year-classes are predicted at recruitment to the fishable stock.

Purse seine surveys appear to provide a useful means to examine factors controlling recruitment and to evaluate the impact of stock rebuilding strategies in the Strait of Georgia. Because of limited and localized distributions of age-1 lingcod over trawlable bottom in the study area, bottom trawl surveys may be less suited to estimate recruitment.

Key words: lingcod, Strait of Georgia, purse seine, year-class strength

RÉSUMÉ

Cass, A. J. and J. R. Scarsbrook. 1984. A preliminary study of variability in year-class abundance of post-larval and juvenile lingcod in the Strait of Georgia during 1980-82. Can. MS Rep. Fish. Aquat. Sci. 1755: iv + 27 p.

Dans le but d'évaluer l'abondance relative des classes d'âge de 1980 et de 1981 des morues-lingues post-larvaires et âgées de 1+ an, dans le détroit de Géorgie, on a effectué des levés à l'aide de sennes coulissantes et de chaluts de fond. Les densités des post-larves reflètent la forte classe d'âge de 1975. Par conséquent, les fortes classes d'âge de 1980 et de 1981 permettront un recrutement élevé au sein du stock exploitable.

Les levés à la senne coulissante semblent constituer un moyen utile pour examiner les facteurs contrôlant le recrutement et pour évaluer l'incidence des stratégies de régablissement des stocks dans le détroit de Géorgie. À cause des répartitions limitées et localisées des morues-lingues de un an sur le fond chalutable, dans la zone expérimentale, les levés au chalut de fond sont peut-être moins appropriés pour évaluer le recrutement.

Mots clés: morue-lingue, détroit de Géorgie, senne coulissante, abondance d'une classe d'âge

INTRODUCTION

Lingcod stocks off Canada's west coast are characterized by marked fluctuations in year-class abundance. Despite what is perceived as a long-term decline in the abundance of lingcod in the Strait of Georgia (Stocker 1981) a relatively strong 1975 year-class was observed as post-larvae and age-1 juveniles in the southern Strait of Georgia (Phillips and Barraclough 1977; Beamish et al. 1976, 1978). A strong 1975 year-class as age-1 lingcod was also observed in Puget Sound (Moulton 1977).

In recent years, the 1975 year-class has been a dominant feature in the trawl fishery off the west coast of Vancouver Island and in Queen Charlotte Sound (Cass unpublished data) and in the fisheries of Puget Sound (Bargmann 1982). Limited monitoring of the commercial line fishery in the Strait of Georgia suggests the 1975 year-class was also dominant in the late 1970s (Cass unpublished data).

Because lingcod stocks are characterized by periodic surges in recruitment, an understanding of the mechanisms controlling year-class abundance is important to successful fisheries management of lingcod.

In the Strait of Georgia, management strategies were recently adopted in an attempt to rebuild depleted stocks. While the reason for stock decline has not been clearly established, over-fishing is suspected (Ketchen 1980, Westrheim 1980, Stocker 1981). Specifically, beginning in 1979 the existing annual winter fishing closure (December-February) was extended by two months (November 15-April 15) to more appropriately cover the pre-spawning aggregation, spawning and nesting periods (Low and Beamish 1978). The extension of the closure was designed to reduce the catch during the reproductive period, a period of high vulnerability to fishing, and to provide greater protection to nest-guarding males. The presence of the nest-guarding male during nest incubation is essential to egg survival (Low and Beamish 1978), and consequently forms a primary basis for maintaining lingcod stocks.

This report examines variations in the relative strengths of the 1980 and 1981 year-classes of post-larval and age-1 lingcod in the Strait of Georgia as part of long-term studies of factors controlling year-class abundance and monitoring the impact of stock rebuilding strategies in the Strait of Georgia. Densities of pelagic post-larval and demersal age-1 lingcod were estimated from purse seine and bottom trawl surveys, respectively.

METHODS

PURSE SEINE SURVEYS

Relative strengths of the 1980 and 1981 year-classes of post-larval lingcod were estimated from purse seine surveys of the nearshore waters of the southern Strait of Georgia (Fig. 1). Surveys were conducted during the April-June period of pelagic development as determined from Phillips and Barraclough (1977). The geographic distribution of sampling effort was selected to compare results of our study with those of Phillips and Barraclough (1977).

The area surveyed in all years encompassed about 50 km^2 in the nearshore waters of the southwestern Strait of Georgia (Fig. 2). In 1980, the survey was expanded southward to encompass as large an area as possible (320 km^2), given sampling time and effort constraints. Sampling in 1981 was less intense than during other years and was confined to the main survey area north of Dodd Narrows.

In an attempt to sample the range of habitats available to pelagic stages of young lingcod, as identified by Phillips and Barraclough (1977), the following generalized regions were sampled:

a) Midstream and shoreline areas in current-swept channels where the majority of newly hatched larvae are likely to appear.
b) Exposed regions of mixed waters where larvae are likely to be swept by surface currents.
c) Sheltered areas which may act as potential rearing areas of post-larval lingcod.

All stations in 1980 and 1981 were sampled using a 275 m x 18 m purse seine equipped with a 5 mm knotless nylon stretched mesh bunt (Fig. 3). Sets were conducted from the research drum seiner R/V TAHLOK. Phillips and Barraclough (1977), using a multiple depth Miller net, established that pelagic stages of lingcod are confined to the upper 3 m of the water column. Results of bathymetric readings during an unrelated study (Scarsbrook and McDonald 1970) indicated the 18 m deep purse seine samples to depths of 12-14 m when set. The depth range sampled by the purse seine was therefore considered suitable to sample the vertical distribution of pelagic lingcod.

In 1980, stations were sampled at weekly intervals during April 22-June 6. In 1981, stations were sampled at weekly intervals during May 7-28. All stations were sampled during daylight hours. During the second weekly interval in 1980, 3 stations were also sampled at night to compare day and night distributions.

During the initial two sampling periods in 1980 (April 22-23 and April 30-May 2) modified bongo nets (McGowan and Brown 1966) were also used immediately before or immediately after each seine set to compare catch densities and selectivity properties of the purse seine and bongo samplers. Bongo samplers had 57 cm net openings with General Oceanic flow meters centrally suspended within each opening. A 350 μ black nitex net was attached

to each half of the sampler. The bongo sampler was towed within the upper 3 m of the water column from an 11 m boom off the starboard side of the vessel.

In addition, during 1980 selected shallow water stations in sheltered regions of the study area were sampled using small purse seines and beach seines to determine if these sites, as identified by Wilby (1937) and Phillips and Barraclough (1977), were used as rearing areas by pelagic and newly settled demersal lingcod. Sampling at these sites was conducted during June 11-12, 1980. Twenty-five stations (<8 m) were sampled (Fig. 4) using a 90 m x 5 m hand-operated purse seine equipped with a 1.3 cm stretched mesh bunt. Sampling at shallow water stations was conducted from the research vessel R/V MELIBE. A cursory examination of the intertidal eelgrass and oyster bed habitat of Departure Bay was conducted using a 30 m x 5 m beach seine equipped with 1.3 cm stretched mesh netting.

Catches of lingcod were preserved in a 5% buffered formalin solution. Lingcod were counted and measured for fork length by set. In those sets containing a large number of lingcod, a random sampled of 200 was measured for length.

BOTTOM TRAWL SURVEYS

Previous bottom trawl surveys conducted near the Gulf Islands at biweekly to monthly intervals in 1975 and 1976 resulted in seasonally and annually varying catches of age-1 lingcod (Beamish et al. 1976; 1978). The 1975 year-class was found to be relatively abundant and present in highest concentrations during February with catches of age-1 lingcod highly localized near Porlier Pass. Bottom trawling was conducted in the same area in 1981 and 1982 to monitor the relative strengths of the 1980 and 1981 year-classes as age-1 lingcod.

A 14 m commercial stern trawler, the M/V GAMBLER I, was chartered during both 1981 and 1982. A standard west coast bottom trawl equipped with a 2 cm stretched mesh codend liner was used on all tows. The same trawl gear was used in both years. In 1981 ten tows were completed during February 27-28. Of these, 6 were completed at Porlier Pass and 4 were completed near Nanaimo. In 1982, nine sets were completed during February 22-23 in Trincomali Channel between Porlier and Active passes (Fig. 5).

After each tow all lingcod were counted and measured for fork length. Age-1 lingcod were identified from length-frequency distributions. Densities of the 1980 and 1981 year-classes were estimated as the number caught per distance towed.

RESULTS

POST-LARVAE

Nine lingcod were caught using bongo samplers in the nine tows completed during the first sampling interval (April 22-23). During the second sampling interval (April 30-May 4) no lingcod were caught using bongo nets in the 12 tows completed. Due to the small sample size of lingcod captured, bongo sampling was judged to be an ineffective method of sampling surface waters for young lingcod. We believe the ineffectiveness of the bongo sampler to catch lingcod was due to the presence of dense blooms of brown algae in surface waters that restricted the filtering capacity of the net. For this reason, bongo sampling was discontinued after the second sampling interval.

A comparison of mean lengths of lingcod in bongo net catches with mean lengths in purse seine catches during April 1980, indicates the purse seine selectively samples for larger lingcod. Although based on a small sample size, the mean length of lingcod caught during bongo sampling was 12 mm. The mean length of lingcod caught during purse seining was 28 mm. These data indicate newly hatched larvae (6-12 mm in length) were ineffectively sampled by the purse seine.

Numbers of lingcod caught during purse seining within each sampling interval by set in 1980 and 1981 are presented in Table 1 and 2, respectively.

Night seining during the second sampling interval in 1980 resulted in lower catch rates compared to daytime sampling. Night seining at Hammond Bay (Stn 1) and Horsewell Channel (Stn 3) resulted in a 66% decline in catch rates from daytime sampling within a 24-hr period. Night seining in Departure Bay (Stn 25) resulted in the capture of large concentrations of ctenophores that prevented a quantitative comparison of day and night densities. The decline in catch rates between day and night sampling, although based on a small sample size, indicated young pelagic age-0 lingcod were less concentrated in surface waters at night. For this reason, density estimates were made from day sets only.

Densities of lingcod within each sampling interval were estimated as the geometric mean[a] number caught per set and per km^2 (Table 3). To allow a comparison of densities among year-classes, densities of the 1975 and 1976 year-classes were re-estimated using the same procedure. This was considered appropriate since the original data (Schmidt et al. 1978, 1979), like the 1980-81 data, approached a log normal distribution.

In the main survey area sampled in 1975-76 and 1980-81, the timing of the build-up and decline in lingcod densities was similar in all years (Fig. 6). Maximum densities of young lingcod in surface waters occurred within a 1-wk period in mid-May. During this period estimated densities

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[a] Numbers caught per set were increased by one prior to log transformations to permit zero values in the estimation procedure.

varied by about an order of magnitude ranging from a low of 900 lingcod km^{-2} (95% C.L. = 370 - 2100) in 1976 to a high of 10,200 lingcod km^{-2} (95% C.L. = 4900 - 21,400) in 1980. The difference among years was significant (analysis of variance; $p<0.05$). However, as shown in Fig. 6, the difference was largely due to the low densities of the 1976 year-class. There was no significant difference ($p>0.05$) between densities of the 1975, 1980, and 1981 year-classes.

The inside waters of the Gulf Islands did not appear to be an important rearing area for pelagic stages of young lingcod in 1980 compared to the more exposed waters near Nanaimo. During mid-May 1980, post-larval lingcod in the Gulf Islands area were significantly less abundant (t-test; $p<0.05$) than in the northern survey area. Therefore, catches from the inside waters of the Gulf Islands were excluded in our comparison of year-class strength.

Densities of post-larval lingcod in surface waters declined to low levels by early June in all years. The decline in abundance in 1980 and 1981 corresponded to the first appearance of juvenile lingcod in shallow water catches where the net fished on bottom. This was also reported by Phillips and Barraclough (1977) during the 1975 and 1976 surveys. However, inshore sampling on bottom using the hand-operated purse seine at selected inshore stations (Fig. 4) during June 11-12, resulted in the capture of few lingcod. Catches ranged from 0-13 lingcod per set in the 15 sets completed and averaged 2 lingcod per set. Cursory examination of the intertidal zone in Departure Bay using beach seines resulted in the capture of only one lingcod in the four sets completed. The small catches at these inshore sites in 1980 cannot be considered representative of the distributions of newly settled lingcod. However, Phillips and Barraclough (1977) report a build-up of post-larval lingcod inshore during late May and early June.

Growth of post-larval lingcod was examined from the relationship between total length and time of capture during purse seine sampling. Mean lengths by set during each survey year are plotted in Fig. 7. As reported by Phillips and Barraclough (1977) the slow rate of change in length during April is considered to be more related to recruitment and sampling bias than growth. The rapid rate of growth during May and early June appears more representative. For all years combined, lingcod grew almost linearly from an average of 28 mm to 67 mm during May or at a rate of 1.4 mm/d. During May there was no significant difference in growth rates (slope) among years (analysis of covariance; $p>0.05$). However, there was a small but significant difference ($p<0.05$) in the elevation of the growth curves suggesting that growth had varied at some earlier period of development.

JUVENILES

As was found in previous trawl surveys (Beamish et al. 1976; 1978) concentrations of age-1 lingcod in 1981 and 1982 were highly localized in the vicinity of Porlier Pass. Catches at Porlier Pass accounted for 90% of the total catch in both 1981 and 1982.

Bottom trawling conducted in 1981 in the exposed areas north of Dodd Narrows was restricted by a low availability of trawlable bottom. Echo soundings of this area indicated that the majority of the bottom within depths of 100 m was characterized by high relief rocky areas unsuitable for trawling. For this reason, it was not possible to adequately examine the distribution of juvenile lingcod within the nearshore regions of the study area.

In Departure Bay, where above average concentrations of pelagic post-larval lingcod were found during purse seine surveys, only 4 age-1 juvenile lingcod were caught in the four sets completed.

Estimates of relative strengths of age-1 lingcod were restricted to catches at Porlier Pass. As observed in 1976 (Beamish et al. 1978), age-1 lingcod in 1981 and 1982 were present as a single dominant mode in the length frequency distribution ranging from 23-34 cm (Fig. 8). In contrast, age-1 lingcod in 1975 (1974 year-class) were clearly less abundant compared to adjacent year-classes (Beamish et al. 1976) suggesting recruitment of the 1974 year-class was less than in the other 3 years. These data show that variations in the relative abundance of age-1 lingcod in length-frequency distribution may provide a useful means of identifying strong year-classes at age-1.

Catch rates of the 1980 and 1981 year-classes, estimated as the mean catch per distance trawled, were similar (Table 4) with no significant difference among year-classes (t-test; $p>0.05$). These data indicate that the 1980 and 1981 year-classes, being present at similar densities at age-0, underwent similar rates of mortality up to age-1.

DISCUSSION

There are several potential sources of error in this study affecting the reliability of density estimates as follows: 1) variability in the availability of lingcod among survey years, 2) non-random distribution of lingcod with respect to station location and, 3) variability in the catchability of the gear among stations. While the extent of these errors has not been specifically examined, the similarity in the timing and build-up and decline of post-larval densities in surface waters among survey years suggests density estimates are not seriously masked by sampling errors.

The relationship between parental stock size, egg survival and recruitment cannot be established without more extensive studies. However, under a general hypothesis that strong year-classes in the fishable stock are pre-determined by the post-larval stage, results of this study predict above average recruitment of the 1980 and 1981 year-classes to the fishable stock in the mid-1980s at levels similar to the 1975 year-class.

In the past, data collection and scientific analysis of the commercial and, particularly, the sports fisheries in the Strait of Georgia

have not been well developed. However, studies have recently been initiated to establish a catch at age data base for lingcod in the Strait of Georgia. In conjunction with catch at age data, purse seine surveys of post-larval lingcod appear to provide a useful means of monitoring the impact of stock rebuilding strategies in the Strait of Georgia and to examine factors controlling year-class abundance.

Because of the limited and localized distribution of juvenile lingcod over trawlable bottom, bottom trawl surveys may be less suitable to index recruitment.

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Table 1. Numbers of post-larval lingcod caught by set and sampling interval in surface waters of the Strait of Georgia using the 275 m purse seine during April 21-June 6, 1980.

Stn no.	April 21-23	April 30-May 2	May 7-8	May 13-17	May 21-28	May 31 - June 6
1	51	12 (4)[a]	52	109	5	31
2	-	-	17	11	6	0
3	0	26 (9)	62	38	7	2
4	-	13	64	137	39	0
5	-	-	-	37	2	2
6	1	11	16	590	59	0
7	-	-	-	1	4	3
8	-	-	-	227	0	3
9	-	-	-	72	252	0
10	-	-	-	0	2	1
11	-	-	-	312	7	3
12	8	61	-	649	550	0
13	-	-	-	21	113	3
14	3	8	35	110	28	2
15	-	-	10	5	0	1
16	-	-	61	120	102	0
17	19	10	0	335	8	3
18	-	-	2	1	8	0
19	1	94	3	3	2	1
20	-	-	7	136	12	0
21	1	58	0	44	73	0
22	-	-	-	48	1	0
23	-	-	-	40	1	1
24	-	-	-	5	1	1
25	122	16	48	642	18	2
26	-	-	57	1828	4	15
27	-	-	-	0	2	0
28	-	-	-	4	1	10
29	-	-	-	11	8	0
31	-	-	-	3	75	0
32	-	-	-	66	2	1
33	-	-	-	0	106	21
34	-	-	-	2	0	3
35	-	-	-	87	1	1
36	-	-	-	-	44	2
37	-	-	-	0	1	0
38	-	-	-	11	6	1
39	-	-	-	0	2	0
40	-	-	-	0	3	0

[a]Catches in parenthesis were from night sets.

Table 2. Numbers of post-larval lingcod caught by set and sampling interval in surface waters of the Strait of Georgia using the 275 m purse seine during May 7-28, 1981.

Stn no.	May 7	May 15-16	May 22-28
1	1	193	3
3	29	3	0
4	10	528	1
8	1	18	1
9	53	34	2
25	27	10	19
31	3	9	1

Table 3. Geometric mean numbers of post-larval lingcod per set and per km^2 estimated from purse seine catches in the Strait of Georgia.

Sampling period	G.M. per set	95% C.L.	G.M. per km^2	95% C.L.
		1975 Survey		
April 3-7	0.041	0.038-0.05	12	11-14
April 14-18	1.3	0.6-2.2	371	171-629
April 21-23	0.8	0.4-1.7	229	114-486
April 25-30	7.9	3.7-17.2	2257	1057-4914
May 5-7	4.8	2.2-10.3	1371	629-2943
May 12-15	17.2	5.8-51.0	4914	1657-14571
May 21-22	3.7	1.0-13.2	1057	286-3771
May 27-30	3.4	1.7-6.8	971	486-1943
June 3-6	3.0	0.7-12.1	857	200-3457
June 9-13	0.9	0.5-1.54	257	139-440
June 16-18	0.1	0.09-0.12	29	26-34
		1976 Survey		
April 21-22	1.4	0.1-1.8	397	28-514
April 27-30	1.2	1.1-1.3	343	314-371
May 3-4	0.8	0.5-1.3	229	143-371
May 10-11	0.4	0.3-0.6	114	89-171
May 18-20	3.1	1.3-7.5	886	371-2143
May 25-June 3	0.1	0.07-0.8	28	20-229
June 8	0.3	0.2-0.4	86	57-114
June 16	0.07	0.06-0.08	20	17-23
		1980 Survey[a]		
April 21-23	5.9	2.0-17.6	1000	338-2983
April 30-May 2	21.6	12.8-36.4	3661	2169-6170
May 7-8	19.2	7.8-47.1	3254	1322-7983
May 13-17	60.3	28.8-126.4	10220	4881-21424
May 21-28	13.0	6.7-25.3	2203	1136-4288
May 31-June 6	1.2	0.8-1.8	203	136-305
		1981 Survey		
May 7	8.7	3.0-23.8	1475	536-4039
May 15-16	30.4	8.4-110.5	5152	1423-18729
May 27-28	1.9	1.0-3.9	322	169-661

[a]Estimates were calculated from catches taken at stations within the survey area sampled in 1975 and 1976.

Table 4. Catch rates of age-1 lingcod during bottom trawling at Porlier Pass, M/V GAMBLER I, February 27-28, 1981, and February 22-23, 1982.

	1980 Year-class	
Set no.	No.	CPUE[a] (no./km)
1	29	5.6
2	34	12.5
3	2	9.7
4	25	12.0
5	6	8.6
6	32	11.5
Mean		10.0 ±2.08

	1981 Year-class	
Set no.	No.	CPUE[a] (no./km)
1	23	10.5
2	37	13.2
3	15	8.8
4	11	4.2
Mean		9.2 ± 3.7

[a]Estimated as the number caught per distance trawled.

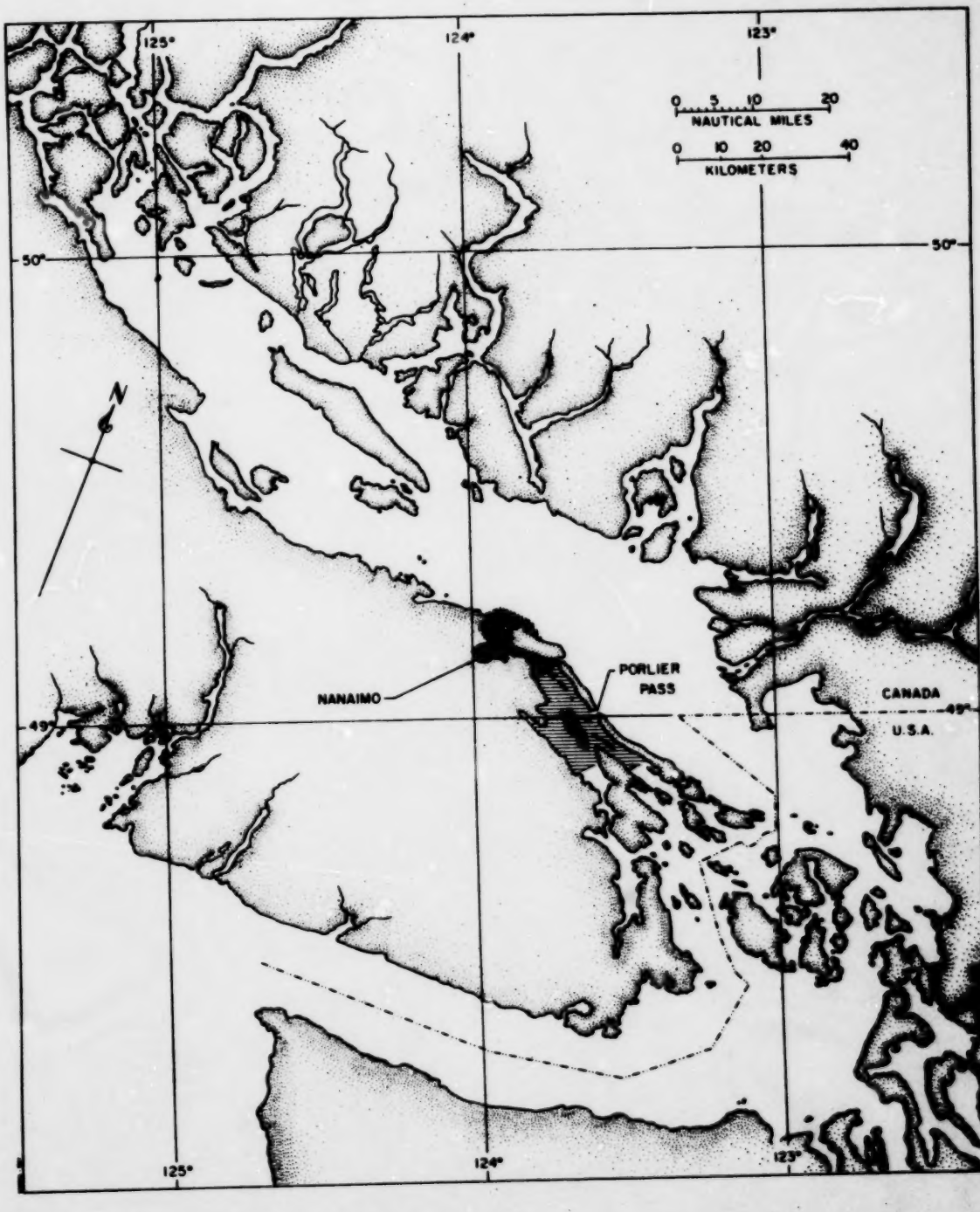

Fig. 1. Location of study area during purse seine surveys for post-larval lingcod in 1980 and 1981. The double-hatched area was surveyed in both 1980 and 1981. The single-hatched area was surveyed in 1980 only.

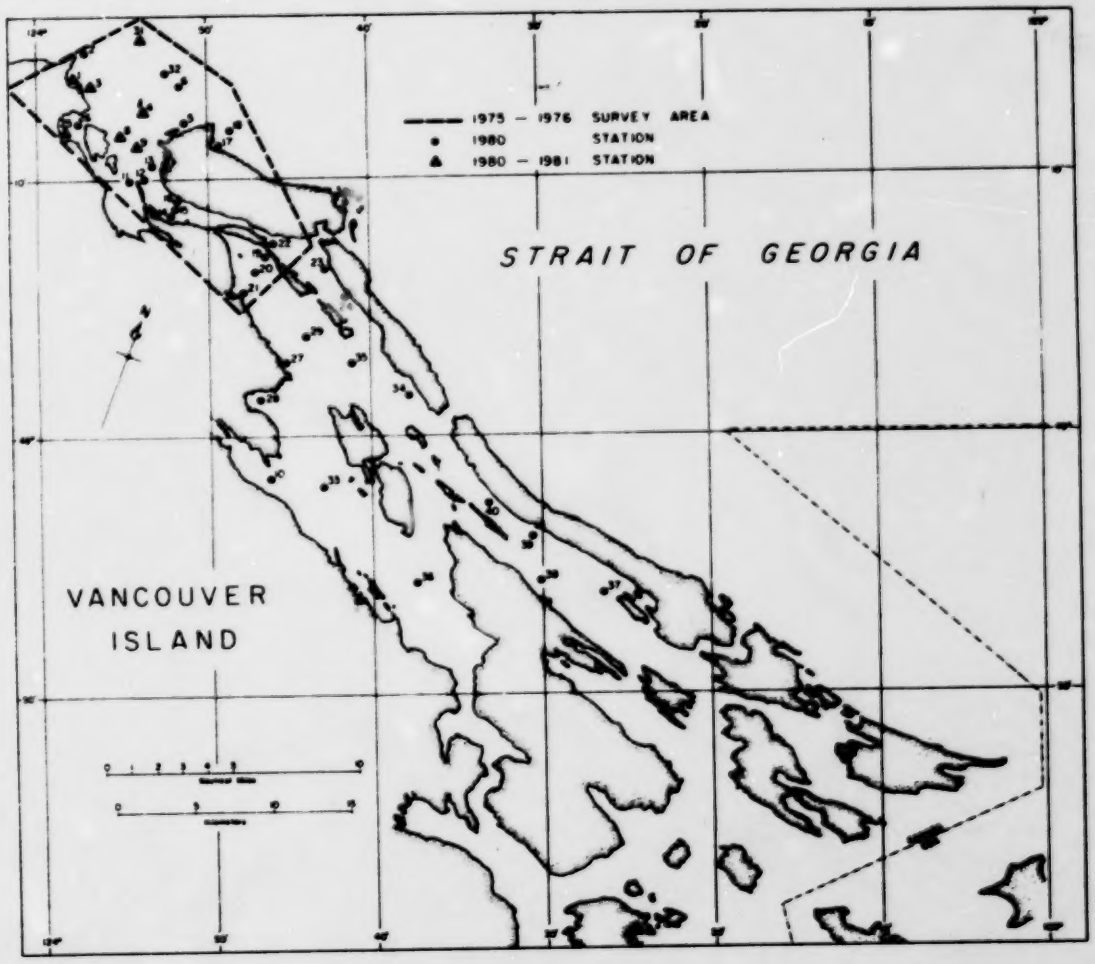

Fig. 2. Set locations sampled using the 275 m x 18 m purse seine during post-larval lingcod surveys in the Strait of Georgia in 1980 and 1981.

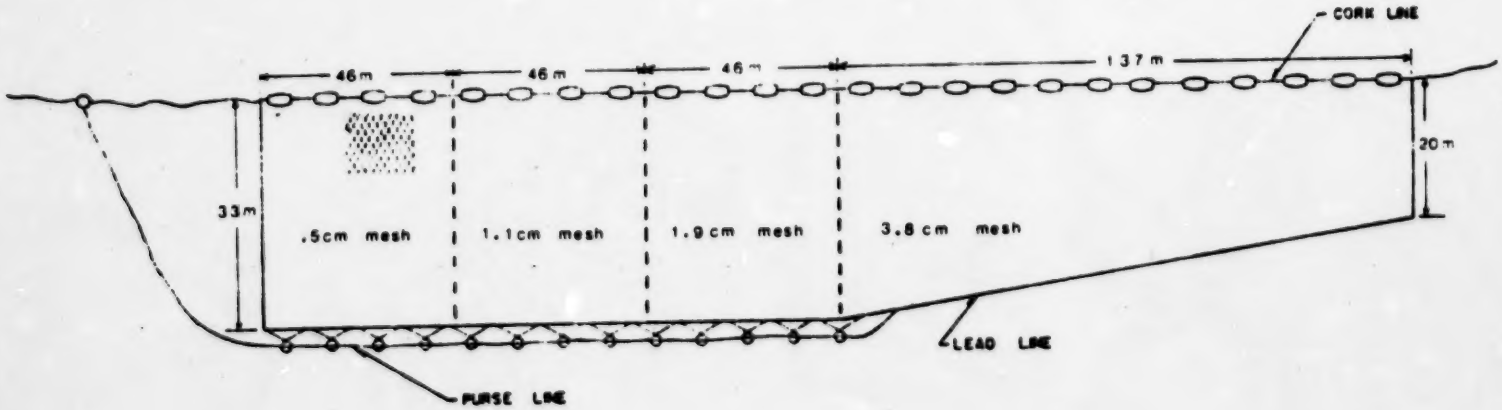

Fig. 3. Dimensions of the 275 m x 18 m purse seine used during post-larval lingcod surveys in the Strait of Georgia in 1980 and 1981.

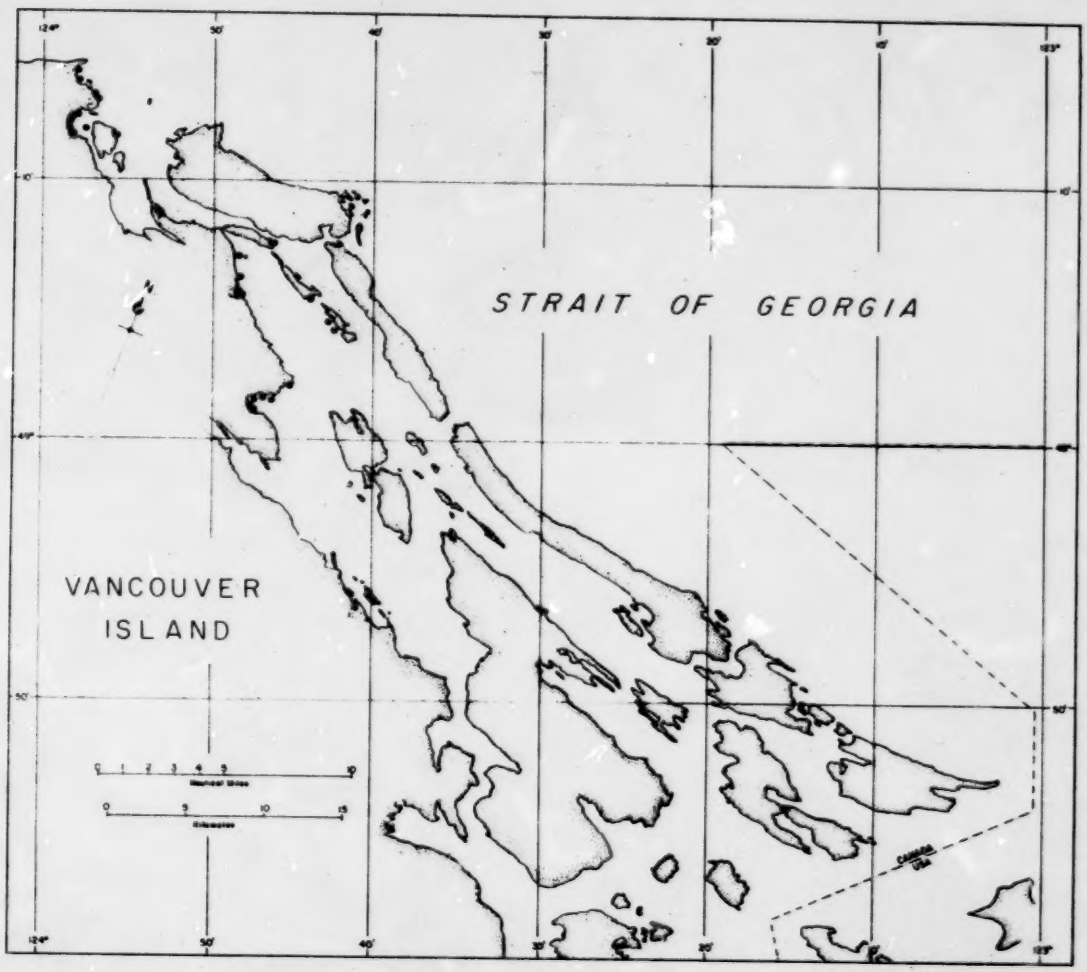

Fig. 4. Set locations sampled using the 90 m x 5 m purse seine during post-larval lingcod surveys in the Strait of Georgia in 1980.

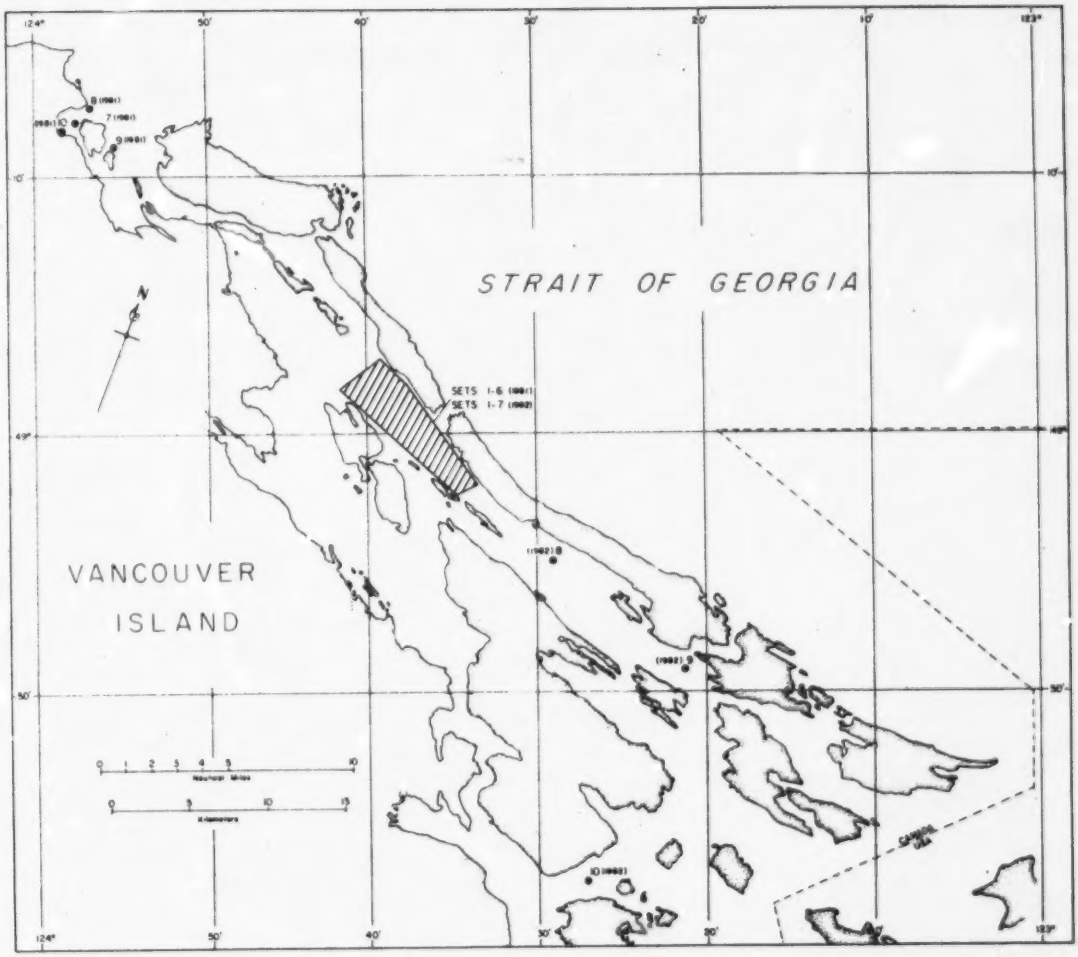

Fig. 5. Set locations sampled during bottom trawling for age-1 lingcod in the vicinity of the Gulf Islands in 1981 and 1982.

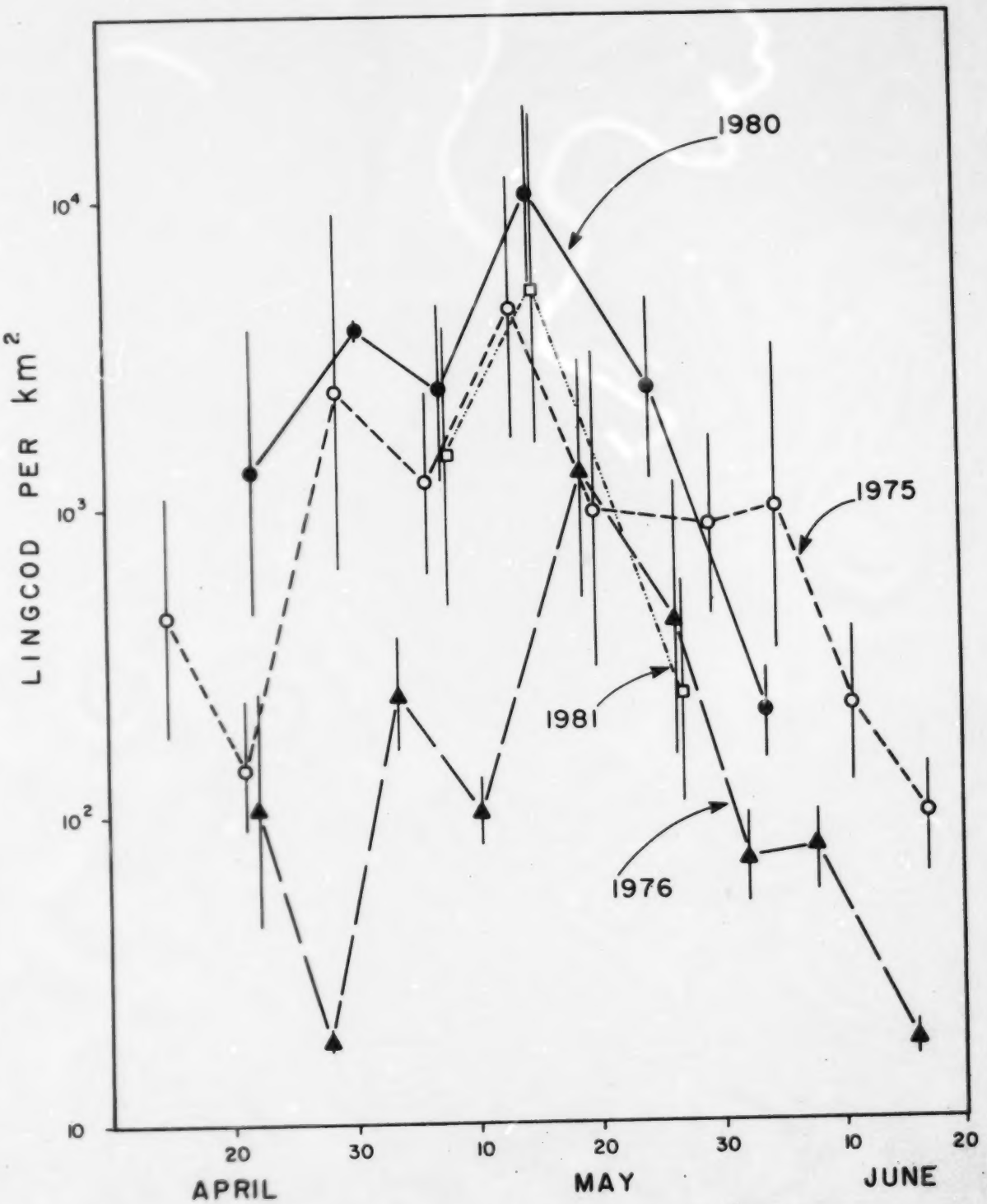

Fig. 6. Densities of post-larval lingcod estimated from purse seine surveys in the Strait of Georgia during the spring period of maximum surface water concentration.

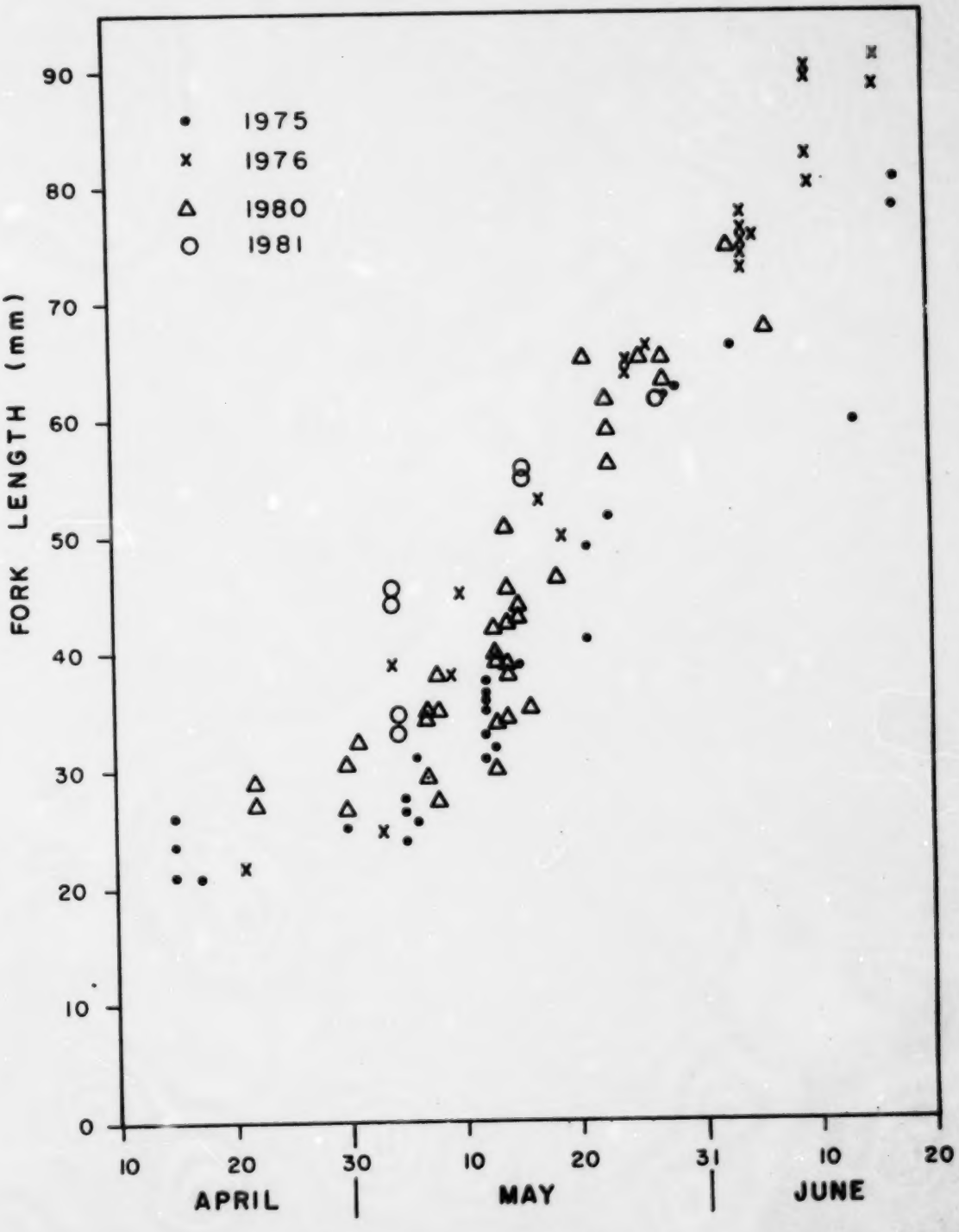

Fig. 7. Mean length of lingcod per station and sampling interval during post-larval purse seine surveys in the Strait of Georgia.

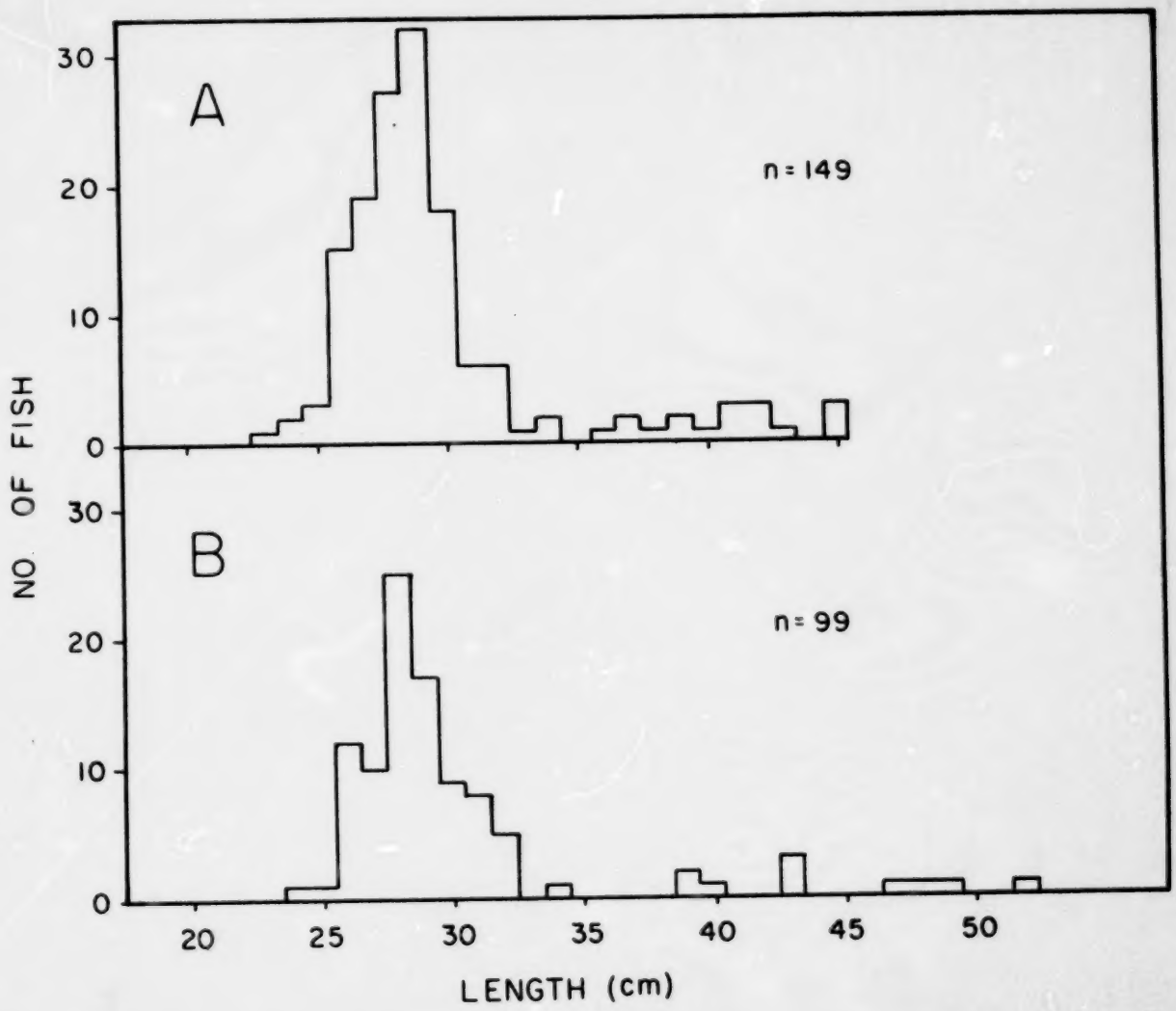

Fig. 8. Length-frequency histograms of lingcod caught at Porlier Pass during bottom trawling in (a) February 27-28, 1981 and (b) February 22-23, 1982.